

What is claimed is:

- 1 1. A method for cleaning glass substrates comprising immersing a glass substrate
2 having lanthanide oxide particles thereon in an acid bath comprising nitric acid,
3 hydrogen peroxide and an organic acid having a carboxylic acid group.
- 1 2. The method of claim 1, wherein the glass substrate is an aluminosilicate glass.
- 1 3. The method of claim 1, wherein the lanthanide oxide particles include at least
2 one oxide of a lanthanum series element selected from the following: lanthanum,
3 cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium,
4 terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.
- 1 4. The method of claim 1, wherein the lanthanide oxide particles include at least
2 one of lanthanum oxide and cerium oxide.
- 1 5. The method of claim 1, wherein the glass substrate is immersed in the acid
2 bath at a temperature of at least about 40°C.
- 1 6. The method of claim 1, wherein the glass substrate is immersed in the acid
2 bath at a temperature of about 55°C to about 70°C.
- 1 7. The method of claim 1, wherein the nitric acid in the acid bath is at least about
2 1N nitric acid.
- 1 8. The method of claim 1, wherein the nitric acid in the acid bath is about 3N to
2 about 4N nitric acid.
- 1 9. The method of claim 1, wherein the hydrogen peroxide in the acid bath is at
2 least about 0.15N hydrogen peroxide.

- 1 10. The method of claim 1, wherein the hydrogen peroxide in the acid bath is
2 about 0.15N to about 1N hydrogen peroxide.
- 1 11. The method of claim 1, wherein the organic acid is tartaric acid, citric acid,
2 lactic acid, gluconic acid or edetic acid.
- 1 12. The method of claim 1, wherein the acid bath includes at least about 0.0067M
2 organic acid.
- 1 13. The method of claim 1, wherein the acid bath includes about 0.02 to about
2 0.04M organic acid.
- 1 14. The method of claim 1, wherein the acid bath includes at least about 0.0067M
2 tartaric acid.
- 1 15. The method of claim 1, wherein the acid bath includes about 0.02 to about
2 0.04M tartaric acid.
- 1 16. The method of claim 1, wherein the acid bath further includes about 0.03 to
2 about 0.15 vol.% of a surfactant.
- 1 17. The method of claim 16, wherein the acid bath includes about 0.1 vol.% of the
2 surfactant.
- 1 18. The method of claim 1, wherein the acid bath further includes up to about 1N
2 sulfuric acid.
- 1 19. The method of claim 1, wherein the acid bath further includes up to about 40
2 g/l boric acid.
- 1 20. The method of claim 1, wherein the acid bath further includes aluminum ions.

1 21. The method of claim 20, wherein the acid bath includes up to about 0.005N
2 $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$.

1 22. The method of claim 1, wherein the glass substrate is immersed in the acid
2 bath for at least about 4 minutes.

1 23. The method of claim 1, wherein the glass substrate is immersed in the acid
2 bath for about 4 minutes to about 5 minutes.

1 24. The method of claim 1, further comprising scrubbing the glass substrate with
2 polyvinyl alcohol pads and potassium hydroxide having a pH of between about 9 and
3 about 12.

1 25. The method of claim 24, further comprising immersing the glass substrate in a
2 basic bath of potassium hydroxide having a pH of between about 11.5 and about 13
3 subsequent to the step of immersing the glass substrate in the acid bath.

1 26. The method of claim 1, further comprising subsequently subjecting the glass
2 substrate to chemical strengthening, and immersing the glass substrate in a mild
3 etching bath comprising a surfactant and an acid selected from the group of organic
4 acids and sulfuric acid.

1 27. The method of claim 1, further comprising subsequently subjecting the glass
2 substrate to chemical strengthening, and immersing the glass substrate in a mild
3 etching bath comprising nitric acid, boric acid, hydrogen peroxide and an organic acid
4 having a carboxylic acid group.

- 1 28. A method for cleaning glass substrates comprising:
2 immersing a glass substrate having lanthanide oxide particles thereon in an
3 acid bath comprising at least about 1N nitric acid, at least about 0.15N hydrogen
4 peroxide and at least about 0.0067M tartaric acid; and
5 subsequently immersing the glass substrate in a basic bath of potassium
6 hydroxide having a pH of between about 11.5 and about 13.
- 1 29. The method of claim 28, wherein the glass substrate is an aluminosilicate
2 glass.
- 1 30. The method of claim 28, wherein the lanthanide oxide particles include at
2 least one of lanthanum oxide and cerium oxide.
- 1 31. The method of claim 28, wherein the glass substrate is immersed in the acid
2 bath at a temperature of at least about 40°C.
- 1 32. The method of claim 28, wherein the glass substrate is immersed in the acid
2 bath at a temperature of about 55°C to about 70°C.
- 1 33. The method of claim 28, wherein the nitric acid in the acid bath is about 3N to
2 about 4N nitric acid.
- 1 34. The method of claim 28, wherein the hydrogen peroxide in the acid bath is
2 about 0.15N to about 1N hydrogen peroxide.
- 1 35. The method of claim 28, wherein the acid bath includes about 0.02 to about
2 0.04M tartaric acid.
- 1 36. The method of claim 28, wherein the acid bath further includes about 0.03 to
2 about 0.15 vol.% of a surfactant.

1 37. The method of claim 36, wherein the acid bath includes about 0.1 vol.% of the
2 surfactant.

1 38. The method of claim 28, wherein the acid bath further includes up to about 1N
2 sulfuric acid.

1 39. The method of claim 28, wherein the acid bath further includes up to about 40
2 g/l boric acid.

1 40. The method of claim 28, wherein the acid bath further includes aluminum
2 ions.

1 41. The method of claim 40, wherein the acid bath includes up to about 0.02N
2 $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$.

1 42. The method of claim 28, wherein the glass substrate is immersed in the acid
2 bath for at least about 4 minutes.

1 43. The method of claim 28, wherein the glass substrate is immersed in the acid
2 bath for about 4 minutes to about 5 minutes.

1 44. The method of claim 28, further comprising scrubbing the glass substrate with
2 polyvinyl alcohol pads and potassium hydroxide having a pH of between about 9 and
3 about 12.

1 45. The method of claim 28, further comprising subsequently subjecting the glass
2 substrate to chemical strengthening, and immersing the glass substrate in a mild
3 etching bath comprising a surfactant and an acid selected from the group of tartaric
4 acid and sulfuric acid.

- 1 46. The method of claim 28, further comprising subsequently subjecting the glass
- 2 substrate to chemical strengthening, and immersing the glass substrate in a mild
- 3 etching bath comprising nitric acid, boric acid, hydrogen peroxide and an organic acid
- 4 having a carboxylic acid group.

- 1 47. A method for cleaning glass substrates comprising:
2 (a) polishing a glass substrate with a slurry comprising lanthanide oxide
3 particles;
4 (b) ultrasonically cleaning the substrate;
5 (c) mechanically scrubbing the substrate with soap and a pad;
6 (d) immersing the substrate in an acid bath comprising nitric acid, hydrogen
7 peroxide and an organic acid having a carboxylic acid group;
8 (e) scrubbing the substrate with polyvinyl alcohol pads and potassium
9 hydroxide; and
10 (f) immersing the substrate in a basic bath of potassium hydroxide.

- 1 48. The method of claim 47, further comprising:
2 (g) subjecting the substrate to chemical strengthening;
3 (h) immersing the substrate in an etching bath of a surfactant and an acid
4 selected from the group of organic acids and sulfuric acid;
5 (i) again scrubbing the substrate with polyvinyl alcohol pads and potassium
6 hydroxide; and
7 (j) again immersing the substrate in a basic bath of potassium hydroxide.

- 1 49. The method of claim 48, wherein steps (a)-(j) are each carried out for a time
2 sufficient to reduce the content of lanthanide particles on the glass substrate to less
3 than about 1.52×10^{-4} ng/mm² each after step (j).

- 1 50. A method for manufacturing a disk, comprising:
2 polishing a glass substrate with a slurry comprising lanthanide oxide
3 particles; and
4 cleaning the polished glass substrate to remove said lanthanide oxide particles,
5 said cleaning step leaving no more than about 1.52×10^{-4} ng/mm² of each type of
6 lanthanide oxide on said glass substrate.
- 1 51. The method of claim 50, wherein said cleaning step comprises immersing the
2 substrate in an acid bath comprising nitric acid, hydrogen peroxide and an organic
3 acid having a carboxylic acid group.

1 52. A glass substrate having a polished surface comprising less than about
2 1.52×10^{-4} ng/mm² each of oxide particles of lanthanide series elements selected from
3 the following: lanthanum, cerium, praseodymium, neodymium, promethium,
4 samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium,
5 ytterbium, and lutetium.

1 53. The glass substrate of claim 52, wherein the glass is aluminosilicate glass.

1 54. The glass substrate of claim 52 produced by the method of:
2 polishing the glass substrate with a slurry to an atomically smooth finish, the
3 slurry comprising at least one oxide of a lanthanide series element;
4 immersing the polished glass substrate having residual lanthanide oxide
5 particles thereon in an acid bath comprising at least about 1N nitric acid, at least about
6 0.15N hydrogen peroxide and at least about 0.0067M tartaric acid; and
7 thereafter immersing the glass substrate in a basic bath of potassium
8 hydroxide having a pH of between about 11.5 and about 13.

1 55. A glass substrate having a polished surface comprising less than about
2 1.52×10^{-4} ng/mm² each of oxide particles of lanthanide series elements selected from
3 the following: lanthanum, cerium, praseodymium, neodymium, promethium,
4 samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium,
5 ytterbium, and lutetium, said substrate produced by the method of claim 47.

1 56. A glass substrate having a polished surface comprising less than about
2 1.52×10^{-4} ng/mm² each of oxide particles of lanthanide series elements selected from
3 the following: lanthanum, cerium, praseodymium, neodymium, promethium,
4 samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium,
5 ytterbium, and lutetium, said substrate produced by the method of claim 48.

1 57. A disk drive product comprising a glass substrate having a polished surface
2 comprising less than about 1.52×10^{-4} ng/mm² each of oxide particles of lanthanide
3 series elements selected from following: lanthanum, cerium, praseodymium,
4 neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium,
5 holmium, erbium, thulium, ytterbium, and lutetium.

1 58. The disk drive product of claim 57, wherein the glass substrate is
2 aluminosilicate glass.

CLAIMS

1 1. A self-cleaning colloidal slurry composition for superfinishing a surface of a substrate,
2 the self-cleaning colloidal slurry composition comprising:

3 a carrying fluid;

4 colloidal particles;

5 etchant for etching the substrate;

6 a surfactant adsorbed and/or precipitated onto a surface of at least one of the substrate and
7 the colloidal particles, the surfactant having a hydrophobic section that forms a steric hindrance
8 barrier between the substrate and the colloidal particles.

1 2. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 substrate is selected from a group consisting of a glass disk substrate, a ceramic disk substrate,
3 and a glass-ceramic disk substrate for use in a data storage device.

1 3. The self-cleaning colloidal slurry composition as recited in claim 2, wherein the
2 substrate is a silicate-based glass disk substrate.

1 4. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 colloidal particles include colloidal silica particles, the surfactant is a nonionic surfactant and/or
3 cationic, and the self-cleaning colloidal slurry composition has a pH of approximately 0 to 4.

1 5. The self-cleaning colloidal slurry composition as recited in claim 4, wherein the self-
2 cleaning colloidal slurry composition has a pH of approximately 0.8 to 3.0.

1 6. The self-cleaning colloidal slurry composition as recited in claim 5, wherein the self-
2 cleaning colloidal slurry composition has a pH of approximately 1.0 to 2.0.

1 7. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 colloidal particles include colloidal silica particles, the surfactant is a cationic quaternary amine
3 surfactant, and the self-cleaning colloidal slurry composition has a pH of approximately 7 to 12.

1 8. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 colloidal particles include colloidal alumina or colloidal silica coated with alumina, and the self-
3 cleaning colloidal slurry composition has a pH of approximately 3.5 to 10.5.

1 9. The self-cleaning colloidal slurry composition as recited in claim 4, wherein the
2 colloidal silica particles have a nominal size of approximately 2 - 200 nm.

1 10. The self-cleaning colloidal slurry composition as recited in claim 6, wherein the
2 colloidal silica particles include colloidal silica spheres having a nominal size of approximately 7
3 nm.

1 11. The self-cleaning colloidal slurry composition as recited in claim 3, wherein the etchant
2 is a metal etchant selected from a group consisting of Ce, Zr, Ti, Fe, Sn, Al, Cr, Ni, Mn and Zn,
3 and combinations thereof, and wherein the metal etchant is present in solution and/or as a colloid
4 and/or as an ion on the colloidal particles.

1 12. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the etchant
2 is an acid or base solution.

1 13. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 surfactant is a nonionic and/or cationic surfactant selected from a group consisting of oxygen
3 containing compounds and nitrogen containing compounds, and combinations thereof.

1 14. The self-cleaning colloidal slurry composition as recited in claim 13, wherein the
2 nonionic surfactant is an oxygen containing compound with moieties of ethylene oxide and/or
3 polyvinyl alcohol.

1 15. The self-cleaning colloidal slurry composition as recited in claim 13, wherein the
2 nonionic and/or cationic surfactant is a nitrogen containing compound selected from a group
3 consisting of alkaloids and amines, and combinations thereof.

1 16. The self-cleaning colloidal slurry composition as recited in claim 13, wherein the
2 nonionic and/or cationic surfactant is a polydentate adsorption surfactant.

1 17. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 surfactant is a cationic surfactant.

1 18. The self-cleaning colloidal slurry composition as recited in claim 1, wherein the
2 surfactant is selected from a group consisting of anionic surfactants and quaternary amine
3 surfactants.

1 19. A process for superfinishing a surface of a substrate, the process comprising the steps
2 of:
3 applying a self-cleaning colloidal slurry to the surface of the substrate, the self-cleaning
4 colloidal slurry comprising
5 a carrying fluid,
6 colloidal particles,
7 etchant for etching the substrate,
8 a surfactant adsorbed and/or precipitated onto a surface of at least one of the
9 substrate and the colloidal particles, the surfactant having a hydrophobic section that forms a
10 steric hindrance barrier between the substrate and the colloidal particles;
11 mechanically rubbing the surface of the substrate with a pad while contacting the surface of
12 the substrate with the self-cleaning colloidal slurry.

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1 20. The process as recited in claim 19, wherein the substrate is selected from a group
2 consisting of a glass disk substrate, a ceramic disk substrate, and a glass-ceramic disk substrate
3 for use in a data storage device.

1 21. The process as recited in claim 20, wherein the substrate is a silicate-based glass disk
2 substrate.

1 22. The process as recited in claim 19, wherein the surfactant is a nonionic and/or cationic
2 surfactant selected from a group consisting of oxygen containing compounds and nitrogen
3 containing compounds, and combinations thereof.

1 23. The process as recited in claim 22, wherein the nonionic surfactant is an oxygen
2 containing compound with moieties of ethylene oxide and/or polyvinyl alcohol.

1 24. The process as recited in claim 22, wherein the nonionic and/or cationic surfactant is a
2 nitrogen containing compound selected from a group consisting of alkaloids and amines, and
3 combinations thereof.

1 25. The process as recited in claim 22, wherein the nonionic and/or cationic surfactant is a
2 polydentate adsorption surfactant.

1 26. The process as recited in claim 19, wherein the surfactant is a cationic surfactant.

1 27. The process as recited in claim 19, wherein the surfactant is selected from a group
2 consisting of anionic surfactants and quaternary amine surfactants.

1 28. The process as recited in claim 19, further comprising the step of cleaning the surface
2 of the substrate using standard soap solutions, wherein the cleaning step is performed after the
3 step of mechanically rubbing the surface of the substrate with the pad while contacting the
4 surface of the substrate with the self-cleaning colloidal slurry, and wherein the cleaning step
5 removes substantially all of the remaining contamination from the surface of the substrate, the
6 remaining contamination being at least partially due to the colloidal particles in the self-cleaning
7 colloidal slurry.

1 29. A disk substrate for use in a data storage device, the disk substrate comprising:
2 substrate material having a surface roughness of less than 2 Å; the substrate material being
3 selected from a group consisting of glass, ceramic, and glass-ceramic; and the substrate material
4 having essentially no surface contamination even though the surface of the substrate material was
5 not subjected to a cleaning process that utilized etching or micropolishing or cleaning polish
6 etch, or a combination thereof, to remove contaminants therefrom.

1 30. The disk substrate as recited in claim 29, wherein the substrate material is a silicate-
2 based glass.

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1 31. A data storage disk for use in a data storage device, comprising:
2 a disk substrate comprising a substrate material having a surface roughness of less than 2
3 Å; the substrate material being selected from a group consisting of glass, ceramic, and glass-
4 ceramic; and the substrate material having essentially no surface contamination even though the
5 surface of the substrate material was not subjected to a cleaning process that utilized etching or
6 micropolishing or cleaning polish etch, or a combination thereof, to remove contaminants
7 therefrom;
8 a recording layer applied over at least one surface of the disk substrate.

1 32. The data storage disk as recited in claim 31, wherein the substrate material is a silicate-
2 based glass.

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1 33. A data storage device, comprising:
2 a data storage disk comprising a disk substrate, the disk substrate comprising a substrate
3 material having a surface roughness of less than 2 Å; the substrate material being selected from a
4 group consisting of glass, ceramic, and glass-ceramic; the data storage disk further comprising a
5 recording layer applied over at least one surface of the disk substrate; and the substrate material
6 having essentially no surface contamination even though surface of the substrate material was not
7 subjected to a cleaning process that utilized etching or micropolishing or cleaning polish etch, or
8 a combination thereof, to remove contaminants therefrom;
9 a transducer;
10 an actuator provided to position the transducer relative to the data storage disk;
11 a motor provided to rotate the storage disk relative to the transducer.

1 34. The data storage device as recited in claim 33, wherein the substrate material is a
2 silicate-based glass.

1 35. A self-cleaning colloidal slurry composition for finishing a surface of a substrate, the
2 self-cleaning colloidal slurry composition comprising:

3 a carrying fluid;

4 colloidal particles;

5 etchant for etching the substrate;

6 a surfactant adsorbed and/or precipitated onto a surface of at least one of the substrate and
7 the colloidal particles, the surfactant having a hydrophobic section that forms a steric hindrance
8 barrier between the substrate and the colloidal particles.

1 36. The self-cleaning colloidal slurry composition as recited in claim 35, wherein the
2 colloidal particles have a nominal size of approximately 70 - 200 nm to provide a textured
3 surface on the substrate.

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1 37. A process for finishing a surface of a substrate, the process comprising the steps of:
2 applying a self-cleaning colloidal slurry to the surface of the substrate, the self-cleaning
3 colloidal slurry comprising
4 a carrying fluid,
5 colloidal particles,
6 etchant for etching the substrate,
7 a surfactant adsorbed and/or precipitated onto a surface of at least one of the
8 substrate and the colloidal particles, the surfactant having a hydrophobic section that forms a
9 steric hindrance barrier between the substrate and the colloidal particles;
10 mechanically rubbing the surface of the substrate with a pad while contacting the surface of
11 the substrate with the self-cleaning colloidal slurry.

1 38. The process as recited in claim 37, further comprising the step of cleaning the surface
2 of the substrate using standard soap solutions, wherein the cleaning step is performed after the
3 step of mechanically rubbing the surface of the substrate with the pad while contacting the
4 surface of the substrate with the self-cleaning colloidal slurry, and wherein the cleaning step
5 removes substantially all of the remaining contamination from the surface of the substrate, the
6 remaining contamination being at least partially due to the colloidal particles in the self-cleaning
7 colloidal slurry.

1 39. The process as recited in claim 37, wherein the step of mechanically rubbing the
2 surface of the substrate with a pad while contacting the surface of the substrate with the self-
3 cleaning colloidal slurry provides a textured surface on the substrate.